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Movement Quality in Adolescence depends on the Level and Type of Physical Activity.

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Abstract

Objectives: This study examined the relationship between functional movement and physical activity (PA) levels in adolescents.

Design: Cross-sectional study.

Setting: This research is a part of the ***X*** longitudinal study conducted in a random sample of adolescents in ***X*** at the Faculty of Kinesiology, University of ***X, X***.

Participants: Seven hundred and twenty-five adolescents aged between 16-17 years were included.

Main Outcome Measure: Total Functional Movement Screen score (total FMS score).

Results: After adjusting for age, body fat and SES, both VPA and MVPA showed minor but significant effects on total FMS score among girls (β=0.011, p=0.001, β=0.005, p=0.006, respectively), but not in boys (β=0.004, p=0.158; β=0.000, p=0.780). Regarding PA type, volleyball and dance improved total FMS score (β=1.003, p=0.071; β =0.972, p=0.043, respectively), while football was associated with lower FMS score (β=-0.569, p=0.118).

Conclusion: Results suggest that the PA level is positively associated with the functional movement in adolescent girls, but not in boys, where the type of PA moderates these associations. Therefore, functional movement patterns incorporated into physical education curriculum could be beneficial to the musculoskeletal health of the children.

Keywords: Functional Movement Screen, sport participation, children, movement patterns

INTRODUCTION

Insufficient physical activity (PA) is related to many noncommunicable diseases, shortened life expectancy (Department of Health & Human Services, 2018), leading to a large economic burden and global health problem (Ding et al., 2016). Recent reports have shown that inactive children are exposed to increased metabolic and cardiovascular risk (Janssen & LeBlanc, 2010). Several studies point to the positive effects of regular PA on physical, cognitive, and mental health in children (Janssen & LeBlanc, 2010). In addition to negative consequences of physical inactivity, low levels of PA have been related to suboptimal proprioception (Ribeiro & Oliveir, 2011) and possible decreases in neuromuscular innervation. More importantly, evidence shows that extremely low levels of PA can lead to loss of muscle volume, physiological cross-sectional area, loss of fascicle length, changes of pennation angle and muscle strength as well as deficits in motor control (Campbell et al., 2013) which can potentially lead to dysfunctional movement (Duncan, Stanley & Leddington Wright 2013; Duncan & Stanley, 2012). Dysfunctional movement patterns are defined as compensatory movement patterns in the kinetic chain which are caused by loss of motor control and deficit in mobility and stability of joints (Cook, 2011). In addition, dysfunctional movements can limit exhibition of high intensity PA and may lead to acute or chronic injury (Garrison, Westrick, Johnson & Benenson, 2015; Kiesel, Butler, & Plisky 2014; Shojaedin, Letafatkar, Hadadnezhad & Dehkhoda, 2014). Likewise, some experts believe that dysfunctional movement patterns may lead to structural pathological deformities (Duncan et al., 2013; Duncan & Stanley, 2012; Frank et al., 2013). Bringing this together, low level of PA along with the dysfunctional movement patterns could impact a person’s health.

In contrast, optimal functional movement implies optimal motor control, proprioception, adequate mobility, and stability of the joints and body regions involved in a specific movement (Cook, Burton & Hoogenboom, 2006a; Cook, Burton & Hoogenboom, 2006b; Cook, 2011). It has been shown that exercises that include stability and motor control components lead to better functional movement (Mahdieh et al., 2020). Also, optimal functional movement patterns are prerequisites for performing high-intensity PA and exercises (Cook, 2011). Therefore, practicing functional movement patterns is of fundamental importance for the development of complex motor skills. The most commonly used diagnostic tool to assess functional movement quality is the Functional Movement Screen (FMS^{TM}) (Cook et al., 2006a; Cook et al., 2016b). The FMS^{TM} is a screening tool that evaluates the quality of functional movement by examining seven fundamental movement patterns through the following seven tests: the deep squat, hurdle step, inline lunge, shoulder mobility, active straight leg raise (ASLR), trunk stability push-up, and rotary stability. An overall composite score noted as a total FMS score is calculated by summing the values of the seven FMS^{TM} tests. In this way, lower scores obtained on FMS^{TM} testing indicate less then optimal functional movement (e.g. dysfunctional movement) (Cook et al., 2006a; Cook et al., 2016b). Studies have shown that lower total FMS scores are related to higher injury risk (Bonazza, Smuin, Onks, Silvis & Dhawan, 2017; Krause, Schütz, Taylor & Doyscher, 2014). Furthermore, it has been shown that FMS^{TM} can successfully predict injury occurrence among athletes (Garrison et al., 2015; Kiesel et al., 2014; Shojaedin et al., 2014), while other studies indicate the opposite (Bardenett et al., 2015; Dorrel et al., 2015; Dossa et al., 2014).

In addition to the consequences of dysfunctional movement, the development of dysfunctional movement patterns through adolescence can cause even greater and negative health consequences as inter-segmental and inter-limb coordination, neuromuscular and postural control are not fully matured by the time of adolescence (Quatman-Yates, Quatman, Meszaros, Paterno, & Hewett, 2012). Duncan and Stanley (Duncan & Stanley, 2012) pointed out that developed dysfunctional movement in childhood and adolescence can lead to potential orthopaedic abnormalities in later life. Therefore, acquired optimal functional movement patterns during childhood and adolescence need to be sustained by proper training system and training methods during the adulthood. From the neurodevelopmental standpoint (Frank et al., 2013), the source of dysfunctional movement patterns can be twofold (Mahdieh et al., 2020): *1) lack of PA and exercise*, and *2) repetitive subcortical exhibition of the compensatory movement patterns* in the sensitive growth period. Therefore, investigating how PA influence functional movement during childhood and adolescence needs special attention.

The interest among researches and practitioners in studying functional movement and using the FMS^{TM} across the various populations is constantly increasing (Abraham et al., 2015; Duncan et al., 2013; Duncan & Stanley, 2012; Lester, McGrane, Belton, Duncan, Chambers & O'Brien, 2017; Molina-Garcia et al., 2019). Despite its importance and widespread usage, only a handful of studies have focused on functional movement in the paediatric population (Abraham et al., 2015; Duncan et al., 2013; Duncan & Stanley, 2012; Lester et al., 2017; Molina-Garcia et al., 2019). To date, only two studies examined the relationship between PA and functional movement in children (Duncan & Stanley, 2012; Molina-Garcia et al., 2019), both reporting that a higher level of PA is positively related to total FMS score. While such research is welcome, these aforementioned studies were performed on a small number of conveniently selected children and included only preadolescents. This limits the conclusions that can be drawn in regard to the importance of PA on functional movement in the adolescent population. Therefore, understanding how PA impacts functional movement during adolescence is important and the first step to targeting interventions effectively for health benefit. In particular, to the authors knowledge, there are no studies that investigated the relationship between PA level and functional movement in the general adolescent population. Therefore, the aim of this research was to examine the relationship between PA and functional movement in an urban adolescent population. We hypothesized that a higher PA level will be positively related to the total FMS score in the population of urban adolescents.

METHODS

Participants

All measurements for this investigation were performed in the spring 2015 as part of a longitudinal four-year study (***X***) conducted from 2014 to 2017 in ***X*** (***X***). Details on the sampling and procedures of the study have been described elsewhere (Štefan, Sorić, Devrnja, Podnar, & Mišigoj-Duraković, 2017). In brief, using stratified two-stage random sampling procedures (school level and class level), 86 secondary schools were stratified by type: grammar schools/vocational schools/private schools (***X***). During the first stage of random selection, 13 public (8 vocational and 5 grammar schools) and 1 private school (grammar school) were selected, considering the proportion of different types of schools and the average number of students per school of around 1500. Then, in the second stage of randomization, half of the first-grade classes in each of the selected schools were randomly selected. At the end, 1408 students from 52 classes were enrolled, thus 64% agreed to participate (n=903) (Štefan et al., 2017). Post-hoc power analysis for level-two hierarchically structured data (Browne, Golalizadeh Lahi, & Parker, 2009) for the main predictor (i.e. VPA) revealed that in order to achieve the power of 0.8 with alpha level set at 0.05, the optimal number of classes with the cluster size of one should be 42. The fact that this study included 52 classes with the cluster size ranging from 1 to 18, thus indicates that it was adequately powered to detect associations of the main predictors with the primary outcomes.

One hundred and twenty-five participants were unavailable on the day of testing or did not complete the FMS screening and PA assessment. As a consequence, we included data from 778 adolescents (mean age ± SD=16.6 ± 0.4 years).

All the participants had to meet certain criteria for the medical doctor to perform the screening process, specifically: 1) not having any pain during the movement screening and 2) not having an acute medical condition that precluded FMS™ testing (neurologic disorders or serious orthopedic trauma such as bone fractures or complete muscle ruptures). Accordingly, 53 participants were excluded. Therefore, the total number of participants that was analyzed was 725 adolescents (girls, n = 366; boys, n = 359). The flowchart of the included participants is shown in Figure 1.

Place Figure 1. around here

The Ethics Committee of the Faculty of Kinesiology at the University of ***X*** (***X***) approved the procedures of this study (No: ***X***), which was executed according to the Declaration of

Helsinki. The written consent of the parents or legal guardians of the children was ensured once they have been informed of the study aims, the protocol, and the possible discomforts they might encounter.

Procedures

Outcome: total Functional Movement Screen score

The most widely used screening tool for the assessment of movement quality is the FMS^{TM} (Cook et al., 2006a; Cook et al., 2016b). The FMS^{TM} consists of seven basic movement patterns: the deep squat, hurdle step, inline lunge, shoulder mobility, active straight leg raise, trunk stability push-up, and rotary stability. Ten novice trained raters performed FMS^{TM} assessment using a standardized procedure according to literature (Cook et al., 2006a; Cook et al., 2016b). Evidence demonstrates that two-hour education on using FMS^{TM} as a screening tool is needed to reach acceptable interrater and intrarater reliability (Smith, Chimera, Wright & Warren, 2013). However, our raters underwent two-day education and training procedures by FMS^{TM} certified practitioner. Moreover, two familiarization sessions were conducted to optimize the consistency and accuracy of raters. Each participant had a maximum of 3 trials for each test following the recommended protocol (Cook et al., 2006a; Cook et al., 2016b). Each test was scored on a three-point scale, from 0 to 3, with higher scores indicating better functional movement. It has been shown that pain can alter movement control (Sterling, Jull & Wrigh, 2001). Therefore, participants were asked if they felt pain during the FMS^{TM} testing procedure, and were subsequently excluded if answered positively to the question (n=53). For each test, the highest score from the three trials was recorded. An overall composite score was calculated by summing the seven individual tests with a total FMS score of 21 according to standardized guidelines (Cook et al., 2006a; Cook et al., 2016b).

Main predictors: Physical Activity Level Variables

In order to assess PA, the School Health Action, Planning, and Evaluation System (SHAPES) questionnaire was used to assess PA via a computerized version (Wong, Leatherdale & Manske, 2006). This questionnaire is constituted of 45 multiple-choice questions and was specifically designed for repeated school-based surveys. Two items request a 7-d recall of vigorous PA (VPA) and moderate PA (MPA), respectively. Responses are provided by indicating the number of hours and 15-min increments that each type of PA was performed for each day of the previous week. Therefore, the intensity, duration, and frequency of PA were documented, and the total volume of PA calculated. The average time during the day spent while performing moderate-to-vigorous PA (MVPA) was calculated by summing the weekly time spent performing VPA and MPA divided by 7. Wong et al. (Wong et al., 2006) reported that MVPA estimated using the SHAPES questionnaire correlated moderately with the values of the accelerometer device (r=0.44). The results of this PA questionnaire can be comparable with other instruments for adolescents as prior reliability research using the SHAPES questionnaire showed moderate agreement for moderate and vigorous PA (Wong et al., 2006).

Secondary predictors: Variables of different Type of Physical Activity

The original SHAPES questionnaire was supplemented with two YES/NO questions inquiring about regular participation in organized sports in school, as well as outside of the school. For participants who stated that they participate in organized sport, a comprehensive list of sports activities was offered, and participants identified all the sports in which they reuglarly participated. In this study, participation in different sports activities indicated the type of PA.

Confounders: Body Fat, Socioeconomic Status and Age

Skinfold measurements were taken on the right side of the body at the following sites to the nearest 0.2 mm using Harpenden skinfold calliper (British indicators, West Sussex, UK): 1) triceps fold– at the back of the upper arm, halfway between the acromion process and the olecranon process, 2) subscapular diagonal fold - about 2 cm below the lower angle of the scapula. Body fat percentage was calculated using the Slaughter's equation (Slaughter et al., 1988). All measurements were taken by an experienced technician in triplicate and median values were retained for the analyses.

Socioeconomic status (SES) of adolescents was assessed by using a subjective rating of their perceived socio-economical position within the population. Perceived SES was assessed through a one-item question: “How would you rate your socioeconomic status?”. Responses were as follows: 1- Much lower than average, 2- Lower than average, 3- Average, 4- Higher than average, 5- Much higher than average. Additionally, chronological age was expressed in years and was added in all multilevel model analysis as a confounder.

Data analysis

A multilevel modelling approach was used to examine the effect of different levels of PA on the total FMS score. In this research, we primarily relied on the approach developed by the Centre for Multilevel Modelling – University of Bristol (Rasbash, Steele, Browne & Goldstein, 2019). Multilevel modelling is an elongation of standard multiple regression, where the data have a hierarchical or clustered structure (Rabash et al., 2019). The process of multilevel modelling was divided into three steps. In the beginning, for each predictor, we built the first model (e.g. level-one model). After that, the second model was built (e.g. level-two model) (in this way, the first step of multilevel modelling was completed). Next, these two models were compared with the likelihood ratio test (LR test) and tested for significance (the second step was completed). Thirdly, the model with a better fit was chosen (end of the third step). After the aforementioned three-step process was done, the next model (e.g. three-level model) was introduced and this process was repeated (from first to the third step). To obtain the final model, this process was iterative, resulting in the number of different models in which the model with the best fit was eventually chosen (final model) (Rabash et al., 2019). Only the results of the final models for each predictor are presented in this paper. The simplified workflow of the three-step multilevel approach used in this study is shown in Figure 2. Detailed procedures on the model building are described in the results section.

According to prior evidence from the literature, sex has a significant influence on PA level (Telford et al., 2016) and total FMS score (Abraham et al., 2015) during adolescence. Therefore, the sample was stratified by sex, and all further multilevel analyses were performed separately for boys and girls. We performed two waves of analysis: 1) *a priori* and *2) a posteriori analysis.*

A priori analysis

To examine the effect of different levels of PA on functional movement, the outcome was the total FMS score with the following predictors: MPA, MVPA, and VPA. Each of the predictors was examined in a separate analysis. This approach resulted in six separate analyses (three for girls and three for boys). Based on evidence from the literature, age (Lester et al., 2017) and body composition (Duncan et al., 2013; Duncan & Stanley, 2012; Molina-Garcia et al., 2019) have a significant influence on the FMS score. Also, SES was added as a confounder. Therefore, for each analysis, the confounders of age, body fat, and SES were introduced in all models.

A posteriori analysis

In the second wave, we took the explorative approach to examine which type of PA contributed most to this kind of results. Therefore, in addition to prior analysis, we included sport participation as an additional predictor. In this way, participation in various sports activities (e.g. football, basketball, etc.) was included as a secondary predictor. To investigate which sports activities are most common among boys and girls, frequency tables of participation in various sports were made. Sports activities in which the prevalence was above 15% were considered for further analysis. This approach also resulted in six separate analyses (three for girls and three for boys).

Place Figure 2. around here

In this study, descriptive data are presented as mean values ± SD. Estimates (coefficient) are presented as unstandardized and noted with the beta symbol (β). Multilevel analysis was performed by using statistical package MLwiN (version 3.04) (Charlton, Rasbash, Browne, Healy & Cameron, 2019) while for descriptive analysis statistical package Statistica (version 13.5) was used. The level of the statistical significance was set at $p<0.05$.

RESULTS

Table 1 presents the basic characteristics of participants, stratified by sex. Among girls who participated in sports, the most common sports activities included dance and volleyball, while football, basketball, and combat sports were the most common sports activities among active boys.

In this study, data have a three-level hierarchical structure where students are at level-1, nested within classes at level-2, nested within schools at level-3. However, after calculating variation partition coefficent (VPC) and introducing variance-component models at level-one, level-two and level-three, the data showed significant clustering only at level-two. This can also be seen after plotting the total FMS score by schools (see Figure 3).

Place Figure 3. around here

To obtain information about how much clustering there was in the data, VPC was calculated and showed substantial clustering at level-two. More specifically, VPC at level-two indicated that 12.89% and 13.38% of total FMS score variation lies within classes (level two), and 87.10% and 86.61% of variation lies between girls and boys, respectively (among girls: VPC=0.1289; among boys: VPC=0.1338). Expressed as an intraclass correlation coefficient (ICC), where VPC=ICC, the correlation in total FMS score within classes is 0.128 for girls, and 0133 for boys. Therefore, clustering at level-two or non-independence exists in our data. When the level-three model was introduced, level-three deviance (D3) did not drop compared to level-two deviance (D2) (among girls: D3=1644.926; among boys: D3=1654.066). On the other hand, D2 dropped by 15.15 and 17.66 points compared to level-one deviance (D1) among girls and boys respectively (among girls: LR=D1–D2=1669.031-1653.881=15.15; among boys: LR=D1–D2=1662.58-1644.93=17.66). In addition, quantile-quantile plots (Q-Q plots) were performed to assess assumptions made about residuals for the class (level-two) and students (level-one) level according to the literature (Rabash et al., 2019). The plots showed an approximately straight line, suggesting that the normality assumption at level-two is reasonable (see Supplement file1 and 2). Therefore, all further models were built at level-two.

Place Table 1. around here

Following this, the three-step multilevel approach was carried on. First, the random-intercept model was built and included one of the predictors (e.g. VPA) and all confounders (age, SES, and body fat percentage). After that, a random-slope model for one of the predictors (e.g. VPA) was built. Next, these models were compared with a likelihood ratio test (LR test). LR test was performed to choose the model with a better fit according to the literature (Rabash et al., 2019). After that, the model with a better fit was chosen. Finally, in all analyses, all coefficients of predictor variables were modelled as random at level-two. This approach resulted in six separate analysis and the results are presented in the paragraphs below (Table 2 and 3). The coefficients in the tables are mean unstandardized coefficients representing relationships between total FMS score and the various dependent measures (predictors). Within the all analyses, the addition of confounders did not result in the improvement of the fit statistic as well as in the statistical significance of the associated coefficient. Because nonsignificant confounders can influence the predictor coefficient they were retained in the models (Skelly, Dettori & Brodt, 2012). Data from 83 participants were missing for body fat. Since the MLwiN package can handle missing data, all analyses were carried out regularly and included body fat as a confounder. Also, age was centered around the value of 17 (coded as Age-17).

Results of a priori analysis

Effect of different levels of PA on total FMS score in Girls

In the evaluation of the effects of MVPA, MPA, and VPA level on total FMS score, models with the best fit in girls resulted in random-intercept models at level-two. When the model was adjusted for age, SES, and body fat percentage, MVPA, and VPA showed minor but significant effects on total FMS score (β=0.005, p=0.006; β=0.011, p=0.001, respectively). However, slope coefficients for MPA failed to reach statistical significance (β=0.004, p=0.157) (see Table 2).

For example, in the above analysis of the relationship between total FMS score and VPA in girls, the slope coefficient for VPA was estimated to be 0.011 and it is shared by all classes (see Table 2 for the results). This means that a 100-minutes increase in daily VPA, therefore, corresponds to a 1.1 points increase in total FMS score, holding other confounders constant. When evaluating these coefficients, it is important to consider that each of the coefficients represents a relationship that was adjusted for the other confounders because age, SES, and body fat percentage were included in every analysis.

Place Table 2. around here

Effect of different levels of PA on total FMS score in Boys

In boys, the evaluation of the effects of MVPA, MPA, and VPA level on total FMS score, resulted in random-intercept models at level-two as the models with the best fit. When the model was adjusted for age, SES, and body fat percentage, MVPA and MPA slope coefficients failed to show statistical significance (β=0.000, p=0.78; β=-0.002, p=0.455). However, the VPA slope resulted in a more relevant but not statistically significant coefficient (β=0.004, p=0.158) (see Table 3). MVPA, MPA, and VPA were not significant predictors of total FMS score in boys as was seen in girls, even after adjusting for relevant confounders from the literature. To examine why these discrepancies in results exist, *a posteriori* explorative analysis were carried that included PA type as an additional explanatory variable.

Place Table 3. around here

Results of a posteriori analysis

To investigate the potential influence of the type of PA on total FMS score, *a posteriori* explorative analysis were carried on with sport participation as an additional explanatory variable (secondary predictor). In these analyses, sport participation denotes the type of PA. Among girls who participated in sports, the most common sports activities included dance (30%) and volleyball (25%). However, football (36%), basketball (18%) and combat sports (15%) were the most common sports activities among active boys. Therefore, in the second wave of analysis, all previous models included additional predictors – football, basketball and combat sports (for boys), and volleyball and dance (for girls). This was done by adding and excluding each predictor one by one in all analyses. If a student did not participate in a particular sport, it was coded as 0 (zero), while the value of 1 was coded if that participant participated in a specific sport.

After including the type of PA in the models for girls, the coefficient for the main predictors (e.g. MPA) did not change and remained insignificant (see Appendix 1). However, different types of PA were related to higher total FMS score in girls (when MPA was main predictor, β for dance was 0.972 with a p-value of 0.043; β for volleyball was 1.003 with a p-value of 0.071) (See Table 4). For detailed results and effects of a particular type of PA and confounders on the total FMS, score see Appendix 1 (Tables A1-A3).

Place Table 4. around here

Interestingly, among boys, significance and slope coefficient for VPA changed after including participation in football (β for VPA changed from 0.004 to 0.005, and p-value changed from 0.173 to 0.089, β for football was -0.569 with a p-value of 0.118) (see Table 5 and Appendix 1 for detailed results). After the inclusion of the type of PA (basketball and combat sports), none of the additional predictors reached statistical significance while investigating relations between MVPA, MPA, or VPA and total FMS score (see Table 5). For detailed results see Tables A4-A6 in Appendix 1). Although this change did not reach statistical relevance according to the classic statistical approach, these results are showing a positive trend considering the relationships between VPA and FMS score among boys, after the inclusion of the type of PA. This means that type of PA may have an effect on the total FMS score both in girls and boys.

Place Table 5. around here.

DISCUSSION

This is the first study to examine the relationship between PA and functional movement in the adolescent population. The results presented here are unique and extend scientific understanding of the role that functional movement plays in establishing positive trajectories of PA in youth. Our results demonstrate that MVPA and VPA are significant predictors of total FMS score in adolescent girls ($\beta=0.005$, $p=0.006$ and $\beta=0.011$, $p=0.001$, respectively). Moreover, the results of this study show, for the first time, that the way in which type of PA influences FMS score is different among boys and girls. In girls, participation in dance was a significant predictor of total FMS (β for dance participation=0.97, $p=0.043$). However, among boys, neither of predictors showed a significant contribution to the total FMS score.

Our results, using a large adolescent sample, are in line with previous studies, performed with children, that showed similar relationships between these variables. To date, two similar studies have investigated the relation between PA and FMS in children and young adolescents (Duncan & Stanley, 2012; Molina-Garcia et al., 2019). Prior work by Duncan and Stanley (Duncan & Stanley, 2012), investigated 10-11-year-old children (n=58), reported that total FMS score was significantly positively related to PA ($r=0.301$). In this study BMI and PA were both significant predictors of functional movement, predicting 60.2% of the variance in total FMS score, whereas average steps/day predicted 7.3% of the variance in total FMS score (p=0 .0001, Adjusted R2 =0 .602). Molina-Garcia et al. (2019) found that fitness level was positively related to the total FMS score. The results presented by Molina-Garcia et al. (Molina-Garcia et al., 2019) suggested that children with a higher level of fitness showed better movement quality, independent of their fatness level. Although these prior studies were performed on different populations of children (aged from 8 to 12 and obese children and young adolescents), the results of the current study align with the prior work of Duncan and Stanley (Duncan & Stanley, 2012) and Molina-Garcia et al. (Molina-Garcia et al., 2019).

Although our research confirms some previous findings, a potential explanation in the mentioned studies is still lacking (Duncan & Stanley, 2012; Molina-Garcia et al., 2019). The questions that remain open are: 1) Why is this relationship positive? and 2) What are the mechanisms behind this relationship? Although this cross-sectional study revealed a weak relationship between PA levels and functional movement, we suggest two main potentially overlapping relationships behind this phenomena: *1) Neuromuscular relationship:* A higher PA level is usually related to better motor coordination and motor proficiency (Wrotniak, Epstein, Dorn, Jones & Kondilis, 2006), and postural control (Baghbani, Woodhouse & Gaeini, 2016), which can, in turn, be related to a better quality of movement patterns. At the same time, evidence suggests that a lower level of PA is related to suboptimal proprioception (Ribeiro & Oliveir, 2011) and may limit motor control leading to dysfunctional movement patterns; *2) Psychomotor relationship:* Children who are more engaged in PA and sports activities have a wider variety of movement patterns. Through sports activities and practices, children are engaged in the motor learning process where they learning different movement patterns. It has been shown how multiple motor learning experiences can enhance motor adaptability (Seidler, 2004). This could have a positive effect on movement quality. However, our findings suggest that the psychomotor and neuromuscular relationship between movement patterns and type of PA can be specific. According to the results of our study, it seems that engaging in different types of sports activities has a different effect on movement quality.

More specifically, our results indicate that there might be a positive relationship between volleyball and the movement quality in girls. This may be because volleyball players are more familiar with FMS patterns as similar movement patterns are more common in this sport (squat, shoulder flexion, in-line lunge). In addition, female volleyball players have greater flexibility than other athletes (Dopsaj, 1994). Our results show that this is also true for dancers, as female dancers show better postural control, balance, proprioception, motor control (Kilroy, Crabtree, Crosby, Parker & Barfield, 2016), and better joint mobility during the adolescent period (Steinberg et al., 2006). These factors can have a positive effect on movement quality. However, based on another screening tool, Lee et al. reported that pre-professional dancers also have high levels of injury and suboptimal movement quality during the adolescent period (Lee, Reid, Cadwell & Palmer, 2017). Conversely, the results of this study indicate that participation in football is negatively related to movement quality among boys. Although this relationship did not reach statistical significance, it is important to note that previous studies have shown that football players are exhibiting progressive limitation in flexibility and joint mobility through adolescence (Cejudo et al., 2019) and have a greater risk for degenerative hip joint problems already at the early age of adolescence (de Silva, Swain, Broderick & McKay, 2016). Therefore, future studies should specifically address the differential influence of various PA on movement quality of children and adolescents. As opposed to football, participation in basketball was not significantly related to functional movement in boys. There is obvious sex difference in relation between different types of PA and functional movement. In this study, girls are in the last stage of maturation, while boys are not which could potentially influence quality of movement in both sexes. This can also explain the difference between boys and girls related to the association between type of PA and functional movement. However, more studies are needed in order to examine effect of maturation on functional movement and different types of PA in the adolescent population.

The results of the present study underline the importance of developing functional movement during childhood and adolescence. Providing children and youth with the opportunity to develop functional movement should be considered a key antecedent in enabling children to lead physically active lives. In other words, intensive PA does not guarantee optimal movement quality since engaging in some type of sport activities, especially when exercise intensity is higher than a person's physical fitness level, can result in dysfunctional movement patterns. Conclusively, from a practical point of view, our findings could be incorporated into practice as follows: 1) functional movement patterns should be practiced in isolated manner, independently of practicing specific sport and other physical activities. In line with this, integration of different injury prevention programs, especially those which facilitate functional movement, such as of '11 + Kids' may be beneficial. 2) Learning a variety of movement patterns, as well as practicing learned movements and activities at moderate-to-vigorous intensity could be beneficial to potentially reduce the risk of injury incidence, potential orthopaedic abnormalities, and cardiovascular diseases in later life.

Strengths and Limitations

Several strengths of this study should be highlighted. To the authors knowledge, this is the first study adequately powered study that has investigated the relationship between functional movement quality and PA level in adolescents. Second, this is the only study that has applied multilevel methodology to predict functional movement via various PA parameters in the pediatric population. This results in less biased results (e.g. ecological fallacy is reduced) and clearer conclusions can be drawn. Finally, this study controls for a multitude of different variables that should allow a more accurate prediction of functional movement in the adolescent population (sex, age, percentage of body fat, and socioeconomic status). However, there are also some limitations that need to be acknowledged. This study has a cross-sectional design that limits causal interpretations. In this research, 10 raters were recruited. However, all raters underwent the same education and FMS testing protocol. In addition, previous studies consistently showed good interrater agreement in FMS scores (Smith et al., 2013; Teyhen et al., 2012). Also, this research included mostly urban adolescent population, while excluding adolescents from rural areas. This can potentially limit the generalizability of the results.

Collectively, the results of the present study provide valuable information for those working in physical education, youth sport, and public health, on the contribution of different levels of PA on functional movement quality of the adolescent population. Further research should focus on the examination of different predictors affecting the movement quality in different populations. Since the application of a multilevel methodology is lacking in this research area, we strongly encourage the application of the multilevel methodology for future researchers when appropriate. This approach will yield a more accurate prediction that in turn could be better translated into practice.

CONCLUSION

To this date, there are no studies that have investigated the relationship between various parameters of PA and functional movement in the mid adolescent population. Our study demonstrates that the level of PA is positively associated with functional movement in adolescent girls, but not in boys, where the type of PA moderates these associations. Developing functional movement during childhood and adolescence should therefore be considered essential for optimal musculoskeletal health. Therefore, undertaking functional movement patterns should be practiced in isolated manner as well as practicing learned functional movement patterns and activities at moderate-to-vigorous intensity could be beneficial to potentially reduce future risk of injury incidence, orthopaedic abnormalities, and cardiovascular diseases in later life.

Declaration of interest: None.

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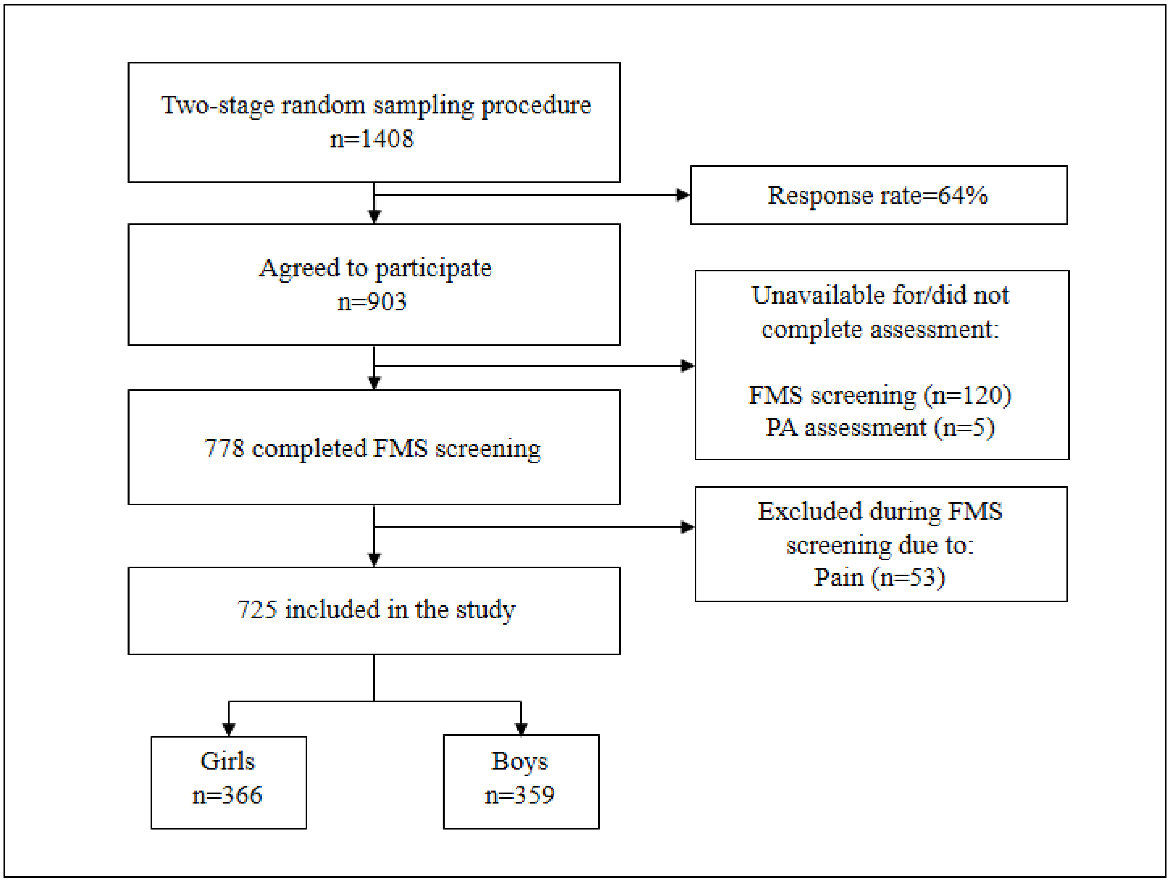

Figure 1. *Flowchart of included participants.*

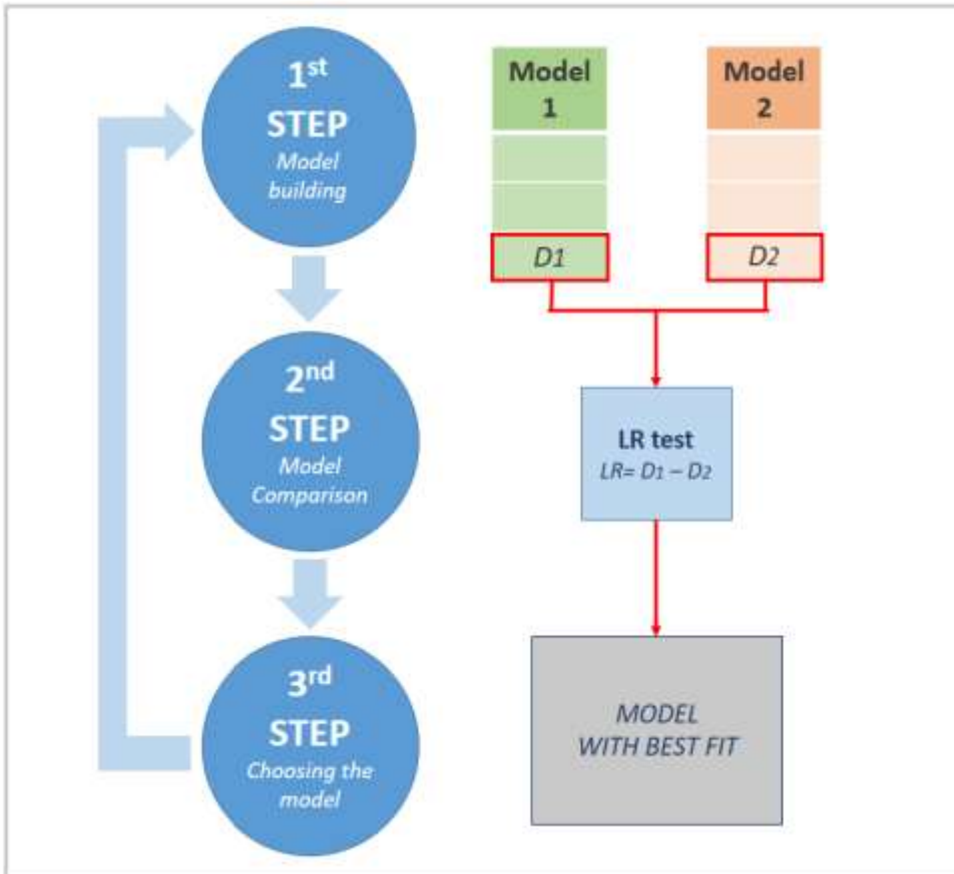

Figure 2. *The simplified three-step multilevel approach.*

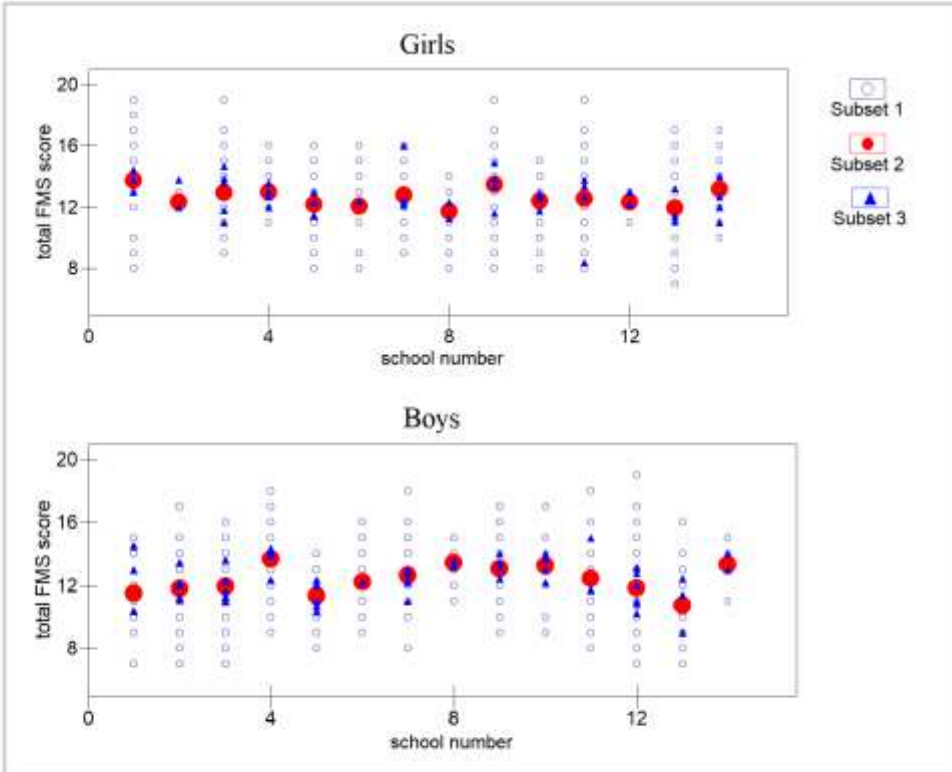

Figure 3. *Scatterplot of total FMS score by school number for boys and girls separately.*

Subset 1 – students, Subset 2- classes, Subset 3- schools.

Table 1. *Basic characteristics of participants stratified by sex.*

	Age (yrs) mean (SD)	Total FMS score mean (SD)	% Body Fat mean (SD)	MVPA (min/day) median (IQR)	MPA (min/day) median (IQR)	VPA (min/day) median (IQR)	Sport part n (%)	School type n (%)		SES median (IQR)
								Voc	Gra	
Boys	16.70 (0.4)	12.23 (2.45)	207 (6.9)	120 (84)	49 (36)	62 (47)	173 (48)	242 (67)	117 (33)	3 (1)
Girls	16.6 (0.4)	12.73 (2.4)	21.5 (5.5)	85 (109)	41 (60)	39 (62)	93 (25)	185 (51)	181 (50)	3 (1)

total FMS score: total Functional Movement Screen score; % Body Fat: Percentage of Body Fat; MPA: Moderate Physical Activity; MVPA: Moderate-to-Vigorous Physical Activity; VPA: Vigorous Physical Activity; Sport part n(%): Number and percentage (%) of participant that participated in sport; School type n (%): number of participant in each type of school; Voc: Vocational school; Gra: Grammar school; SES: socioeconomic status (1- Much lower than average, 2- Lower than average, 3- Average, 4- Higher than average, 5- Much higher than average); IQR: interquartile range; ±SD: ± Standard Deviation.

Table 2. *Level-two random-intercept models for predictors: MPA, MVPA, and VPA for girls.*

response	**total FMS score**								
predictor	**MVPA**			**MPA**			**VPA**		
parameter	**estimate (β)**	**S.E.**	**p**	**estimate (β)**	**S.E.**	**p**	**estimate (β)**	**S.E.**	**p**
Fixed Part									
cons	12.141	0.747	0.000	12.620	0.729	0.000	12.115	0.732	0.000
MVPA	**0.005**	**0.002**	**0.006**	**-**	**-**	**-**	**-**	**-**	**-**
MPA	**-**	**-**	**-**	**0.004**	**0.003**	**0.157**	**-**	**-**	**-**
VPA	**-**	**-**	**-**	**-**	**-**	**-**	**0.011**	**0.003**	**0.001**
%BF	0.017	0.023	0.480	0.017	0.024	0.472	0.015	0.023	0.518
(Age-17)	0.296	0.365	0.417	0.355	0.368	0.336	0.326	0.362	0.368
SES	-0.055	0.164	0.739	-0.103	0.164	0.529	-0.027	0.164	0.870
Random Part									
Level 2 variance	0.727	0.317		0.754	0.328		0.744	0.321	
Level 1 variance	4.760	0.412		4.839	0.418		4.704	0.406	

Cons: intercept; total FMS score: Functional Movement Screen; % Body Fat: Percentage of Body Fat; (Age-17): age centered around the value of 17; MPA: Moderate Physical Activity; MVPA: Moderate-to-Vigorous Physical Activity; VPA: Vigorous Physical Activity; SES: socioeconomic status; estimate (β): unstandardized beta coefficient; S.E.: Standard Error; p: p-value.

Table 3. *Level-two random-intercept models for predictors: MPA, MVPA, and VPA for boys.*

response	**total FMS score**								
predictor	**MVPA**			**MPA**			**VPA**		
parameter	**estimate (β)**	**S.E.**	**p**	**estimate (β)**	**S.E.**	**p**	**estimate (β)**	**S.E.**	**p**
Fixed Part									
cons	12.194	0.657	0.000	12.402	0.629	0.000	11.918	0.651	0.000
MVPA	**0.000**	**0.001**	**0.780**	-	-	-	-	-	-
MPA	-	-	-	**-0.002**	**0.002**	**0.455**	-	-	-
VPA	-	-	-	-	-	-	**0.004**	**0.003**	**0.158**
%BF	0.008	0.019	0.693	0.008	0.019	0.667	0.006	0.019	0.748
SES	-0.050	0.164	0.761	-0.070	0.162	0.666	-0.006	0.165	0.972
(Age-17)	0.042	0.352	0.906	0.039	0.351	0.911	0.098	0.353	0.782
Random Part									
Level 2 variance	0.659	0.313		0.648	0.310		0.679	0.317	
Level 1 variance	5.476	0.457		5.473	0.457		5.431	0.453	

Cons: intercept; total FMS score: Functional Movement Screen; % Body Fat: Percentage of Body Fat; (Age-17): age centered around the value of 17; MPA: Moderate Physical Activity; MVPA: Moderate-to-Vigorous Physical Activity; Vigorous Physical Activity; SES: socioeconomic status; estimate (β): unstandardized beta coefficient; S.E.: Standard Error; p: p-value.

Table 4. *Level-two random-intercept models for predictors MVPA, MPA, and VPA in girls, including different types of PA as the secondary predictors.*

response		**total FMS score**								
parameter		**estimate (β)**	**S.E.**	**p**	**estimate (β)**	**S.E.**	**p**	**estimate (β)**	**S.E.**	**p**
main predictors	**MVPA**	0.004	0.002	0.011	-	-	-	-	-	-
	MPA	-	-	-	0.004	0.003	0.125	-	-	-
	VPA	-	-	-	-	-	-	**0.009**	**0.003**	**0.006**
secondary predictors	**Volleyball**	0.875	0.551	0.112	1.003	0.556	0.071	0.653	0.559	0.243
	Dance	0875	0.480	0.068	**0.972**	**0.481**	**0.043**	0.801	0.482	0.096

total FMS score: Total Functional Movement Screen Score**;** estimate (β): unstandardized beta coefficient; S.E.: Standard Error; p: p-value.; MVPA: Moderate-to-Vigorous Physical Activity; MPA: Moderate Physical Activity; VPA: Vigorous Physical Activity.

Table 5. *Level-two random-intercept models for predictors MVPA, MPA, and VPA in boys, including different types of PA as the secondary predictors.*

response		**total FMS score**								
parameter		**estimate (β)**	**S.E.**	**p**	**estimate (β)**	**S.E.**	**p**	**estimate (β)**	**S.E.**	**p**
main predictors	**MVPA**	-0.002	0.002	0.475	-	-	-	-	-	-
	MPA	-	-	-	-0.002	0.002	0.475	-	-	-
	VPA	-	-	-	-	-	-	**0.005**	**0.003**	**0.089**
secondary predictors	**Football**	-0.412	0.345	0.244	-0.412	0.345	0.244	-0.569	0.364	0.118
	Basketball	0.126	0.473	0.790	**0.126**	**0.473**	**0.790**	0.010	0.473	0.983
	Combat sports	0.129	0.521	0.805	0.129	0.521	0.805	0.055	0.520	0.915

total FMS score: Total Functional Movement Screen Score**;** estimate **(**β): unstandardized beta coefficient; S.E.: Standard Error; p: p-value.; MVPA: Moderate-to-Vigorous Physical Activity; MPA: Moderate Physical Activity; VPA: Vigorous Physical Activity.

APPENDIX 1

Results of a posteriori analysis

Results of a posteriori analysis for girls

Table A1. *Level-two models for predictor MVPA in girls, including type of PA.*

	Model 1	**S.E.**	**p-value**		**Model 2**	**S.E.**	**p-value**	**Model 3**	**S.E.**	**p-value**	**Model 4**	**S.E.**	**p-value**
Response	Total FMS score				Total FMS score			Total FMS score			Total FMS score		
Fixed Part													
cons	12.141	0.747	0.000		12.095	0.744	0.000	12.154	0.743	0.000	12.111	0.740	0.000
MVPA	**0.005**	**0.002**	**0.006**		**0.005**	**0.002**	**0.007**	**0.005**	**0.002**	**0.009**	**0.004**	**0.002**	**0.011**
%BF	0.017	0.023	0.479		0.015	0.023	0.509	0.016	0.023	0.484	0.015	0.023	0.512
SES	-0.055	0.164	0.739		-0.040	0.164	0.806	-0.069	0.163	0.674	-0.054	0.163	0.740
(Age-17)	0.296	0.365	0.417		0.311	0.364	0.393	0.367	0.364	0.313	0.378	0.363	0.298
Volleyball					0.944	0.554	0.089				0.875	0.551	0.112
Dance								0.927	0.481	0.054	0.875	0.480	0.068
Random Part													
Level 2: class													
Var(cons)	0.743	0.322			0.677	0.307		0.856	0.346		0.782	0.330	
Level 1: students													
Var(cons)	4.750	0.410			4.735	0.409		4.642	0.401		4.634	0.400	
Units: class	46				46			46			46		
Units: students	308				308			308			308		
Estimation:	IGLS				IGLS			IGLS			IGLS		
-2*loglikelihood:	1384.454				1.381.603			1.380.884			1.378.410		

Cons: intercept; total FMS score: Total Functional Movement Screen Score; % Body Fat: Percentage of Body Fat; (Age-17): age centered around the value of 17; MVPA: Moderate-to-Vigorous Physical Activity; SES: socioeconomic status; S.E.: Standard Error; Var: Variance.

Table A2. *Level-two models for predictor MPA in girls, including type of PA.*

	Model 1	**S.E.**	**p-value**	**Model 2**	**S.E.**	**p-value**	**Model 3**	**S.E.**	**p-value**	**Model 4**	**S.E.**	**p-value**
Response	Total FMS score			Total FMS score			Total FMS score			Total FMS score		
Fixed Part												
cons	12.620	0.729	0.000	12.587	0.724	0.000	12.510	0.727	0.000	12.487	0.723	0.000
MPA	**0.004**	**0.003**	**0.157**	**0.003**	**0.003**	**0.166**	**0.004**	**0.003**	**0.116**	**0.004**	**0.003**	**0.125**
%BF	0.017	0.024	0.472	0.017	0.023	0.478	0.016	0.024	0.503	0.016	0.023	0.507
SES	-0.103	0.164	0.529	-0.115	0.163	0.482	-0.083	0.164	0.612	-0.095	0.163	0.560
(Age-17)	0.355	0.368	0.336	0.428	0.366	0.243	0.362	0.367	0.323	0.430	0.365	0.238
Volleyball							1.084	0.560	0.053	1.003	0.556	0.071
Dance				1.035	0.482	0.032				0.972	0.481	0.043
Random Part												
Level 2: class												
Var(cons)	0.755	0.330		0.872	0.352		0.679	0.310		0.787	0.331	
Level 1: students												
Var(cons)	4.839	0.421		4.712	0.408		4.813	0.415		4.697	0.406	
Units: class	46			46			46			46		
Units: students	308			308			308			308		
Estimation:	IGLS			IGLS			IGLS			IGLS		
-2*loglikelihood:	1390.059			1.385.628			1.386.376			1.382.442		

Cons: intercept; total FMS score: Total Functional Movement Screen Score; % Body Fat: Percentage of Body Fat; (Age-17): age centered around the value of 17; MPA: Moderate Physical Activity; SES: socioeconomic status; S.E.: Standard Error; Var: Variance.

Table A3. *Level-two models for predictor VPA in girls, including type of PA.*

	Model 1	**S.E.**	**p-value**	**Model 2**	**S.E.**	**p-value**	**Model 3**	**S.E.**	**p-value**	**Model 4**	**S.E.**	**p-value**
Response	Total FMS score			Total FMS score			Total FMS score			Total FMS score		
Fixed Part												
cons	12.115	0.732	0.000	12.123	0.730	0.000	12.142	0.729	0.000	12.150	0.728	0.000
VPA	**0.011**	**0.003**	**0.001**	**0.010**	**0.003**	**0.003**	**0.010**	**0.003**	**0.003**	**0.009**	**0.003**	**0.006**
%BF	0.015	0.023	0.518	0.014	0.023	0.540	0.015	0.023	0.519	0.014	0.023	0.539
SES	-0.027	0.164	0.870	-0.021	0.164	0.896	-0.043	0.164	0.792	-0.037	0.163	0.820
(Age-17)	0.326	0.362	0.368	0.340	0.362	0.347	0.389	0.361	0.281	0.401	0.361	0.266
Volleyball				0.697	0.562	0.215				0.653	0.559	0.243
Dance							0.828	0.483	0.086	0.801	0.482	0.096
Random Part												
Level 2: class												
Var(cons)	0.744	0.322		0.690	0.309		0.847	0.343		0.789	0.329	
Level 1: students												
Var(cons)	4.704	0.406		4.704	0.406		4.611	0.399		4.615	0.399	
Units: class	46			46			46			46		
Units:students	308			308			308			308		
Estimation:	IGLS			IGLS			IGLS			IGLS		
-2*loglikelihood:	1.381.621			1.380.110			1.378.795			1377.458		

Cons: intercept; total FMS score: Total Functional Movement Screen Score; % Body Fat: Percentage of Body Fat; (Age-17): age centered around the value of 17; VPA: Vigorous Physical Activity; SES: socioeconomic status; S.E.: Standard Error;; Var: Variance.

Results of a posteriori analysis for boys

Table A4. *Level-two models for predictor MVPA in boys, including type of PA.*

	Model 1	S.E.	p-value	Model 2	S.E.	p-value	Model 3	S.E.	p-value	Model 4	S.E.	p-value	Model 5	S.E.	p-value
Response	Total FMS score			Total FMS score			Total FMS score			Total FMS score			Total FMS score		
Fixed Part															
cons	12.377	0.630	0.000	12.495	0.638	0.000	12.374	0.632	0.000	12.361	0.633	0.000	12.471	0.641	0.000
MPA	**-0.002**	**0.002**	**0.469**	**-0.002**	**0.002**	**0.490**	**-0.002**	**0.002**	**0.467**	**-0.002**	**0.002**	**0.463**	**-0.002**	**0.002**	**0.475**
%BF	0.009	0.019	0.651	0.008	0.019	0.663	0.009	0.019	0.649	0.009	0.019	0.657	0.008	0.019	0.663
SES	-0.068	0.162	0.676	-0.093	0.163	0.571	-0.068	0.162	0.677	-0.063	0.163	0.700	-0.088	0.164	0.592
(Age-17)	0.031	0.351	0.930	-0.008	0.353	0.982	0.032	0.352	0.927	0.039	0.352	0.912	0.004	0.354	0.992
Football				-0.400	0.349	0.252							-0.412	0.354	0.244
Basketball							0.035	0.467	0.941				0.126	0.473	0.790
Combat sports										0.150	0.522	0.774	0.129	0.521	0.805
Random Part															
Level 2: class															
Var(cons)	0.631	0.306		0.587	0.296		0.631	0.306		0.626	0.305		0.580	0.294	
Level 1: students															
Var(cons)	5.491	0.458		5.493	0.458		5.491	0.458		5.492	0.458		5.494	0.458	
Units: class	51			51			51			51			51		
Units: students	331			331			331			331			331		
Estimation:	IGLS			IGLS			IGLS			IGLS			IGLS		
-2*loglikelihood:	1529.750			1.528.464			1.529.745			1.529.668			1.528.332		

Cons: intercept; total FMS score: Total Functional Movement Screen Score; % Body Fat: Percentage of Body Fat; (Age-17): age centered around the value of 17; MVPA: Moderate-to-Vigorous Physical Activity; SES: socioeconomic status; S.E.: Standard Error; Var: Variance.

Table A5. *Level-two models for predictor MPA in boys, including type of PA.*

	Model 1	S.E.	p-value	Model 2	S.E.	p-value	Model 3	S.E.	p-value	Model 4	S.E.	p-value	Model 5	S.E.	p-value
Response	Total FMS score			Total FMS score			Total FMS score			Total FMS score			Total FMS score		
Fixed Part															
cons	12.377	0.630	0.000	12.495	0.638	0.000	12.374	0.632	0.000	12.361	0.633	0.000	12.471	0.641	0.000
%BF	0.009	0.019	0.651	0.008	0.019	0.663	0.009	0.019	0.649	0.009	0.019	0.657	0.008	0.019	0.663
SES	-0.068	0.162	0.676	-0.093	0.163	0.571	-0.068	0.162	0.677	-0.063	0.163	0.700	-0.088	0.164	0.592
(Age-17)	0.031	0.351	0.930	-0.008	0.353	0.982	0.032	0.352	0.927	0.039	0.352	0.912	0.004	0.354	0.992
MPA	**-0.002**	**0.002**	**0.469**	**-0.002**	**0.002**	**0.490**	**-0.002**	**0.002**	**0.467**	**-0.002**	**0.002**	**0.463**	**-0.002**	**0.002**	**0.475**
Football				-0.400	0.349	0.252							-0.412	0.354	0.244
Basketball							0.035	0.467	0.941				0.126	0.473	0.790
Combat sports										0.150	0.522	0.774	0.129	0.521	0.805
Random Part															
Level 2: class															
Var(cons)	0.631	0.306		0.587	0.296		0.631	0.306		0.626	0.305		0.580	0.294	
Level 1: students															
Var(cons)	5.491	0.458		5.493	0.458		5.491	0.458		5.492	0.458		5.494	0.458	
Units: class	51			51			51			51			51		
Units: students	331			331			331			331			331		
Estimation:	IGLS			IGLS			IGLS			IGLS			IGLS		
-2*loglikelihood:	1529.750			1.528.464			1.529.745			1.529.668			1.528.332		

Cons: intercept; total FMS score: Total Functional Movement Screen Score; % Body Fat: Percentage of Body Fat; (Age-17): age centered around the value of 17; MPA: Moderate Physical Activity; SES: socioeconomic status; S.E.: Standard Error; Var: Variance.

Table A6. *Level-two models for predictor VPA in boys, including type of PA.*

	Model 1	S.E.	p-value	Model 2	S.E.	p-value	Model 3	S.E.	p-value	Model 4	S.E.	p-value	Model 5	S.E.	p-value
Response	Total FMS score			Total FMS score			Total FMS score			Total FMS score			Total FMS score		
Fixed Part															
cons	11.908	0.651	0.000	11.980	0.650	0.000	11.912	0.651	0.000	11.899	0.653	0.000	11.974	0.652	0.000
VPA	**0.004**	**0.003**	**0.173**	**0.005**	**0.003**	**0.084**	**0.004**	**0.003**	**0.169**	**0.004**	**0.003**	**0.177**	**0.005**	**0.003**	**0.089**
%BF	0.007	0.019	0.728	0.006	0.019	0.767	0.007	0.019	0.734	0.007	0.019	0.732	0.006	0.019	0.768
SES	-0.006	0.165	0.973	-0.026	0.165	0.876	-0.005	0.165	0.975	-0.003	0.166	0.987	-0.024	0.166	0.885
(Age-17)	0.087	0.353	0.806	0.050	0.353	0.887	0.084	0.354	0.812	0.092	0.354	0.796	0.053	0.354	0.880
Football				-0.570	0.361	0.114							-0.569	0.364	0.118
Basketball							-0.089	0.471	0.850				0.010	0.473	0.983
Combat sports										0.097	0.521	0.853	0.055	0.520	0.915
Random Part															
Level 2: class															
Var(cons)	0.661	0.312		0.599	0.297		0.663	0.312		0.658	0.311		0.598	0.297	
Level 1: students															
Var(cons)	5.451	0.455		5.443	0.454		5.450	0.455		5.453	0.455		5.443	0.454	
Units: class	51			51			51			51			51		
Units: students	331			331			331			331			331		
Estimation:	IGLS			IGLS			IGLS			IGLS			IGLS		
-2*loglikelihood:	1528.433			1.525.980			1.528.397			1.528.398			1.525.968		

Cons: intercept; total FMS score: Total Functional Movement Screen Score; % Body Fat: Percentage of Body Fat; (Age-17): age centered around the value of 17; VPA: Vigorous Physical Activity; SES: socioeconomic status; S.E.: Standard Error; Var: Variance.